Barrier Coatings and Stability of Thin Film Solar Cells

3rd Quarterly Report - Phase III:
March 1, 2007 -- May 31, 2007

NREL Subcontract: 48027

Subcontractor: **Pacific Northwest National Laboratory**

Principal Investigator: **Larry C. Olsen**

1. OBJECTIVES/APPROACH

The key objectives of the program are to develop low cost barrier coatings for CIS and CdTe solar cells and to develop an improved understanding of the effects of water on the stability of these types of cells. The scope of this work entails investigations of multilayer, barrier coatings for CIS and CdTe thin film solar cells, and studies of stability issues, particularly those related to moisture ingress. Investigation of barrier coatings on SSI and CSU devices will continue in an effort to establish effective approaches to encapsulate CIS and CdTe modules. Studies will also be directed towards issues concerning cost of the coating process. The program will be structured into three major tasks: (1) Barrier coatings and stability studies for CIS Solar Cells; (2) Barrier coatings and stability studies for CdTe solar cells; (3) Low cost coating process development.

2. PROGRESS FOR THIS REPORTING PERIOD

Efforts this past quarter included attendance at 2007 Solar Review, interaction with many of the SAI program winners, and formulation of plans for new studies of barrier coatings on CIGS cells.

3. 2007 SOLAR REVIEW

Since the new SAI program has such a strong emphasis on thin film photovoltaics, our paper presented highlights of work involving barrier coatings applied to CIGS and CdTe solar cells. A copy of the poster is appended. The timing of the Review coming soon after announcements of SAI programs worked out well. Very good interactions were held with all SAI program winners, especially those would be developing CIGS modules on flexible substrates. Discussions were also held with companies pursuing CIGS on flexible substrates that did not have SAI funding.

4. SAI PROGRAMS INVOLVING CIGS ON FLEXIBLE SUBSTRATES

The new SAI programs particularly focus on CIGS technology. In particular, a significant effort will be devoted to 'flexible CIGS.' Companies pursuing CIGS technology are listed in Table 1. The list includes those with and without SAI funding. It appears that all of these industries are going to initially concentrate on glass-to-glass module construction, and then in some cases develop CIGS on flexible substrates. The work carried out on the PNNL program has clearly established that CIGS solar cells are very sensitive to moisture, and therefore must be protected from moisture ingress. It is generally assumed that glass-to-glass module construction will lead to a product that can satisfy Damp Heat stability requirements. In the case of flexible CIGS modules, it is clear that an effective moisture barrier must be applied to the cell surface. The barrier coating must be transparent as well as an effective barrier to moisture ingress. The

Table 1 -- Industries Developing CIGS PV Modules

Industry	CIGS Technology	Comments
Nanosolar	Printing on Glass and Foil	Have SAI Contract
Miasole	Sputter on Glass and Foil	Have SAI Contract
DayStar	Multi -Source Deposition on Glass and Foil	May supply some SAI Contractors
SoloPower	Electroplate on Glass and Foil	
Ascent Solar	Deposition on Polyimide	
Global Solar	Multi-Source Deposition on Glass and Foil	
ISET	Printing	

PNNL multi-layer coatings can provide both of these features. It should also be noted that cost estimates by Vitex (the commercial spin-off from PNNL) indicate that for large volume production, the multilayer coatings could be applied for $ 0.50 per square foot for a 2 dyad coating, and $ 0.70 per square foot for a 5 dyad coating.

5. Future Work

We had hoped to initiate new studies with CIGS this last quarter. Implementing such a study is more a challenge than originally thought. A source of CIGS cells or mini-modules is required before relevant studies can be carried out. IEC has agreed to provide cells for these studies. We will be discussing possible studies with Dr. Shafarman in June to formulate a plan.

Damp Heat Effects on CIGSS and CdTe Cells

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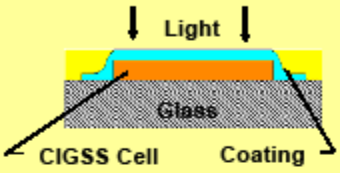
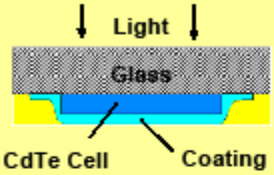
EXPERIMENTAL APPROACH

- Efforts Concentrated on Two Cells :
  - CIGSS from Shell Solar (SSI)
  - CdTe from Colorado State Univ.
- Subjected Devices to 60C/90%RH and 85C/85%RH Environment
- Characterized Stressed Devices with PL and I-V Analyses



CIGSS Substrate Configuration

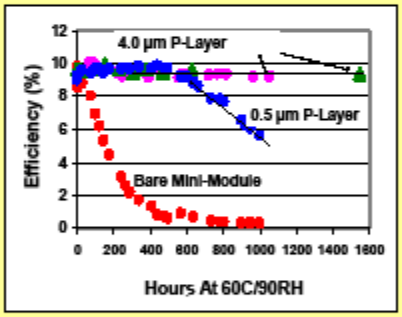


CdTe Superstrate Configuration

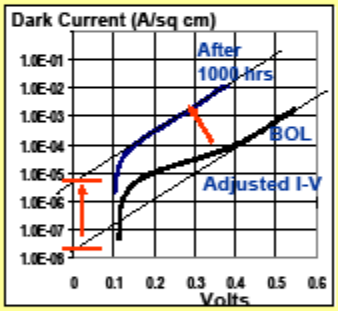
SSI CIGSS MINI-MODULES

- CIGSS Mini-Modules Consist of 10 Cells in Series
- Each Cell was 8.0 cm x 0.7 cm
- Coatings Comprised of 5 Dyads (Polymer/Al_2O_3 Pairs)
- Effects of 1000 hrs @ 60°C/90%RH:

Accelerated Testing Of Coated SSI Mini-Modules

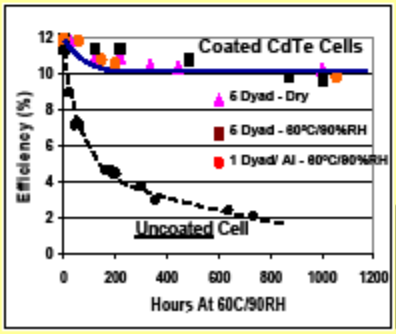


Effect of Damp Heat on Dark I-V Characteristics



CSU CdTe Cells

Accelerated Testing



Photoluminescence Lifetime Studies

CdTe Cell	PL Lifetime
Unstressed	460 psec
85°C / 85%RH For 72 hr	350 psec

Conclusions

Uncoated CIGSS
- All I-V Parameters Degrade
- ZnO more Resistive and Increased Jct Recombination

Uncoated CdTe
- All I-V Parameters Degrade
- PL Indicates Enhanced EH Recombination

PNNL Barrier Coatings
- Polymer/Al_2O_3 Coatings Effective for CIGSS and CdTe
- Cost Models Indicate Barrier Coating can be Applied for < $ 1 / sq ft